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Detailed Description Of The Drawings

A specific method and apparatus is disclosed describing a time shifting technique. In one embodiment, the disclosed time shifting technique can be based upon a hardware transport stream demultiplexer that interfaces to a transport stream. The hardware demultiplexer application assists in the extraction and parsing of a multiplexed packetized data stream, such as a MPEG-2 Transport Stream (TS) multiplex. One such hardware demultiplexer is disclosed in ~~pending~~ patent application (990135), which is hereby incorporated herein by reference. The disclosed hardware transport core is used to filter component streams into 15 memory ring buffers, one allocated in the frame memory for the dedicated MPEG-2 video decoder and others in the system memory for the dedicated software parser. It can demultiplex the most frequent transport packets of video stream into an Elementary Stream (ES) by monitoring the first packet identifier (PID) of each TS packet. This flexible filter can be set to extract private data from the adaptation field (AF) or from the PES packet header. Thirty-one other PIDs can be simply filtered and routed to a common (joint) or individual memory buffers for subsequent software processing on the host processor. The basic idea of a time shifting is shown in Figure 5.

Figure 5 illustrates three functions performed by a time shifting system. A first function is to receive a live broadcast stream 510. According to the graph of Figure 5, the live broadcast stream is continuously received during the time represented in Figure 5.

A second function of a time shifting system is to record a specific program after a user activates the time shifting feature. Vector 520 of Figure 5 indicates when a specific program is being recorded by the time shifting system.

A third function of the time shifting system is to display the specific program. Vector 530 of Figure 5 indicates when a specific program is being played back. Specifically, vector portion 531 represents the time where the program is being displayed directly from the live broadcast stream. Vector portion 532 represents the time that the user is unable to view the program, i.e. the user is away from the television. Therefore, in

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the transport packets to a single memory queue. That way, a temporal order of a stream and validity of T-STD decoder model is already preserved.

In yet another time shifting embodiment, the video is de-multiplexed to the level of elementary stream and stored at the bit-stream buffer of the MPEG video decoder physically allocated in the frame memory. The MPEG video stream is then retrieved from this buffer by a software processing thread running on a host CPU. Every time a picture start code is found in the video bit-stream buffer, a full compressed MPEG picture, in the form of elementary stream, is sent to the system memory buffer by DMA. One such method is disclosed in patent application ~~(990135)~~ <sup>09/489,682</sup> which is hereby incorporated herein by reference.

Before storing the full compressed MPEG picture in the DSM, a PES packet header is added. The audio stream is de-multiplexed and decoded by the host CPU. In a similar fashion as the video, prior to audio decoding, the audio frames are packetized into PES packets. Essential information from the PSI/SI/private data tables is decoded and stored in a pure source form on a DSM. This way, further reduction of the host DRAM memory requirements for queue allocation and memory on the DSM media is reduced. An advantage of this mode is reduction of CPU cycles needed for A/V playback of stored data due to the PES format of audio/video data. PES de-multiplexing is done in place, passing pointers to the payload of PES packets that contain video or audio frames, other implementations required they be sent by DMA to the video decoder before they were decoded on host CPU (MPEG or AC-3 audio). As a result, the host CPU doesn't move any raw audio or video data, and host CPU utilization is reduced in order of magnitude compared to TS playback operating mode.

In the foregoing specification, the invention has been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can be made without departing from the scope of the present invention as set forth in the claims below. For example, the specific time-shifting implementation has been described as with reference to a specific transport stream demultiplexer, and described in a previous applications which have been incorporated by